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Hazards and Threats in Environment of Transboundary Areas

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Abstract

The paper introduces system-oriented definitions of transboundary environmental dangers and threats of economic activities in border areas. The morphology of trans-border hazardous phenomena generated by economic activities in border areas are developed first, and the dangerous effects on objects in the environment of neighboring countries, then and possible harmful impacts on its territory. To illustrate the models lexicological-graphical models were applied. Each of the constituent components of dangers is decomposed in order to derive the basic elements. They are assessed quantitatively by descriptors such as the probabilities of their occurrence. A system structure, allowing understanding in details the content and the dangers and the threats they causes is introduced.

Keywords: transboundary; lexicological-graphical models; harmful impacts.

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1. INTRODUCTION

The dangers and environmental hazards in the border areas have not been defined precisely. Therefore, risk assessment and appearing criticalities are not objective topics. This leads to errors in the national and international information-analytical activity, mistakes in formulating the objectives in forecasting, planning and control in the management of trans-border environmental security. Inaccurate assessments affect the reality and relevance of the situations reproduced by the international regulations and decisions taken on. These acts are often established on the basis of personal experience, intuition and instantaneous subjective understanding of environmental issues.

The purpose of this paper is to define the environmental dangers and hazards of the economic activities in border areas. To achieve the objective must solve the following problems: 1) Morphological modeling of hazards, 2) Defining of the dangers and hazards, 3) Mathematical interpretation, 4) Systematic structure.

2. CONTENT

The differences are: 1) often inaccessible terrain and areas limited infrastructure across national borders, leading to difficulties in international trade, 2) differences in the environmental law, 3) different regulations and opportunities of the state to respond to the environmental hazards phenomennons, 4) different religion and culture, 5) a different language, 6) other powers and resources for disaster response, 7) differences in environmental standards and management; 8) different state regulations on environmental pollution; 9) Variable priorities in international relations; 10) different interpretations of the international agreements, 11) difficult economic opportunities of the bordering countries; 12) unresolved past or present conflicts arising between neighbors 13) differences in the level of technical and organizational security of communications in the border areas and etc.

The introduced differences and non-co-ordinates between neighboring countries usually causes so far not to be taken a single morphological model for precise definitions of dangers and hazards development.

To eliminate these weaknesses some definitions of basic transboundary environmental hazards and threats are adopted:

1. Trans-border environmental dangers are:
   Alleged random in appearance natural and/or anthropogenic phenomennons that cause physical, chemical, biological or hybrid phenomena, - Phenomenons, create dangerous factors and impacts on sites of natural frontier, urban and/or socio - economic environment and cause harmful and/or positive effects of different locations, size, severity,

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and ability to recover". The proposed hypothesis shows that transboundary environmental hazards should be considered as concepts of supposed processes, conditions, circumstances and conditions that must be demonstrated in each situation.

2. "Transboundary environmental threats are proven hypotheses about the dangers that are built for specific hazardous situations," or in other words "transboundary environmental hazards are collections of information on quantitative and qualitative indicators composite system's elements that confirm initially accepted patterns of change and dependencies between the components of the dangers."

Summarizing the above introduced for the trans-border environmental risks they should be understood as hypotheses, and the hazards as proven hypotheses.

For analysis and assessment of transboundary environmental risks modeling method was applied. Its main advantages are: a) increased accessibility and detail determination b) variation of the studied parameters and factors in a lot - a wide range, compared to the original system, c) opportunities for accelerated testing d) fast inspection and acceptance of working hypothesis e) avoid the large financial costs and human resources, expensive measuring equipment, etc. Furthermore, this can reproduce a larger range of conditions, circumstances and other reasons determining the conduct of experimental research.

Some patterns of trans-border environmental hazard phenomenons from economic activities in the border zone are defined and presented in details in (L. Vladimirov, 2009, L. Vladimirov, 2012). They allow revealing the details of their structure. On this basis and applying the basic principles of integrated environmental hazards (L.Vladimirov, 2010, L. Vladimirov, 2011) a new morphological model of trans-boundary environmental hazards was created. It is shown on Figure no.1, no.2 and no.3. A lexicological and graphical representation of the morphology of the models is adopted.

Fig, 1 illustrates the morphology of trans-border environmental hazards phenomenon - $Transphenomenon$, Figure no.2 - environmentally hazardous impacts - $Transimpact$ and Figure no.3 - environmentally danger effects - $Transeffect$.

Using mathematical models a cortege recording of trans-boundary environmental dangers can be represented by the analytical expression:

$$Transecodanger = \{Transphenomenon, Transimpact, Transeffect\}, \quad (1)$$

where $Transphenomenon$ is trans-boundary environmental dangerous phenomenon;

- $Transimpact$ - trans-boundary environmental danger impact,
- $Transeffect$ trans-boundary environmental danger effect.

Each component is a situational system decomposed into situational subsystems, they are decomposes to sub-elements and each element is defined by descriptors. Descriptors are the probabilities of occurrence and time of occurrence of the element of danger.

Thus, sufficiently complete is formalized environmentally danger phenomenons and the ensuing dangers and hazards. It is possible to define their specific parameters.

On the basis of their models the three components of trans-border dangers, respectively, systems of first hierarchical level are composed:

a) $$Transphenomenon = \{F1, F2, F3, F4, F5, F6, F7, F8, F9, F10, F11\}; \quad (2)$$

where $F1, F2, F3, F4, F5, F6, F7, F8, F9, F10, F11$ situational subsystems on second hierarchical level of trans-border environmental danger in the country of origin. Their substance is identified on Figure no.1.

b) $$Transimpact = \{I1, I2, I3, I4, I5, I6, I7, I8, I9, I10, I13, Itr1, Ite2, Itr3, Itr4, Itr5, Itr6, Itr7, Itr8, Itr9, Itr10\}, \quad (3)$$

where $I1, I2, I3, I4, I5, I6, I7, I8, I9, I10, I13$ - situational subsystems of second hierarchical level of environmental impacts in the country of origin, which content is presented at Figure no.2.

$Itr1, Ite2, Itr3, Itr4, Itr5, Itr6, Itr7, Itr8, Itr9, Itr10$ - situational subsystems on the second hierarchical level of hazardous environmental impacts of the country affected, also identified on Figure no.2.

c) $$Transeffect = \{I11, I12, Itr11, Itr12\}, \quad (4)$$

where $I11, I12$ situational subsystem on the second hierarchical level of danger environmental effects of the territory of the country of origin.

$Itr11, Itr12$ - situational subsystem on the second hierarchical level of danger environmental effects of the territory of the affected country.
The two groups were introduced on Figure no.3.
The situational subsystem models of third-level are composed - elements in cortege form are:

$F1 \equiv CAUSE = \{ F1.1, F1.2, F1.3, F1.4, F1.5 \};$

$F2 \equiv PROCESS = \{ F2.1, F2.2, F2.3, F2.4 \}$

$F3 \equiv SOURCE = \{ F3.1, F3.2, F3.3, F3.3, F3.4, F3.5, F3.6, F3.7, F3.8, F3.9 \};$

$F4 \equiv PROFILEPROTECTION = \{ F4.1, F4.2, F4.3 \};$

$F5 \equiv EMISSIONFACTORS = \{ F5.1, F5.2, F5.3 \};$

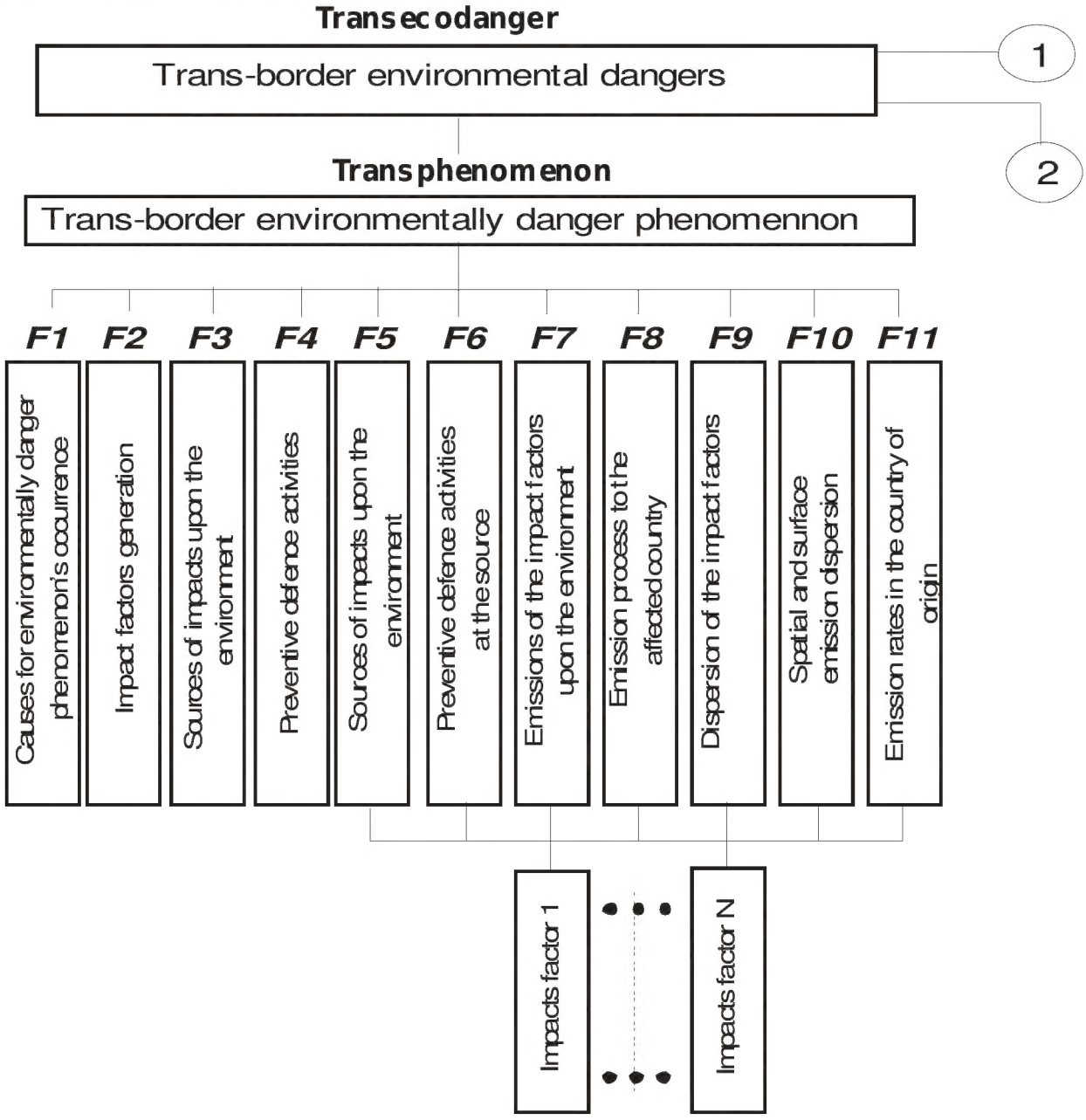

Fig.1.**Lexicological-**graphic **model of transboundary environmental danger phenomenon**

$F6 \equiv EMMISIONPROTECTION = \{F6.1,\ F6.2,\ F6.3,\ F6.4\};$
$F8 \equiv EMISSIONPROCESS = \{F8.1,\ F8.2,\ F8.3,\ F8.4\};$
$F9 \equiv EMISSIONMIDDLE = \{F9.1, F9.2,\ F9.3,\ F9.4\};$
$F10 \equiv EMISSIONSPACE = \{F10.1,\ F10.2\};$
$F11 \equiv EMISSIONNORM = \{F11.1,\ F11.2\};$
$I1 \equiv IMISSIONFACTORS = \{I1.1,\ I1.2,\ I1.3\};$ (5)
$I2 \equiv IMISSIONMIDDLE = \{I2.1,\ I2.2,\ I2.3,\ I2.4\};$
$I3 \equiv IMISSION = \{I3.1,\ I3.2,\ I3.3\};$
$I4 \equiv IMISSIONPROCESS = \{I4.1,\ I4.2\};$
$I5 \equiv IMISSIONSPACE = \{I5.1,\ I5.2\};$
$I6 \equiv IMISSIONNATURE = \{I6.1,\ I6.2,\ I6.3,\ I6.4\};$
$I7 \equiv IMISSIONOBJECT = \{I7.1,\ I7.2\};$
$I8 \equiv IMISSIONCOMMON = \{I8.1,\ I8.2\};$
$I9 \equiv IMISSIONVULNERABILITY = \{I9.1,\ I9.2\};$
$I10 \equiv IMISSIONPROTECTION = \{I10.1,\ I10.2,\ I10.3,\ I10.4,\ I10.5,\ I10.6\};$
$I11 \equiv IMISSIONHARMS = \{I11(1),\ I11(2)\};$
$I12 \equiv RETURNPROTECTION = \{I12.1,\ I12.2\};$
$I13 \equiv IMISSIONTRANSIT = \{I13.1,\ I13.2,\ I13.3,\ I13.4,\ 13.5\};$
$Itr1 \equiv TransIMISSIONFACTORS = \{Itr1.1,\ Itr1.2,\ Itr1.3\};$
$Itr2 \equiv TransIMISSIONMIDDLE = \{Itr2.1,\ Itr2.2,\ Itr2.3,\ Itr2.4\};$
$Itr3 \equiv TransIMISSION = \{Itr3.1,\ Itr3.2,\ Itr3.3\};$
$Itr4 \equiv TransIMISSIONSPACE = \{Itr4.1,\ Itr4.2\};$
$Itr5 \equiv TransIMISSIONPROCESS = \{Itr5.1, Itr5.2\};$
$Itr6 \equiv TransIMISSIONNATURE = \{Itr6.1,\ Itr6.2,\ Itr6.3,\ Itr6.4\};$
$Itr7 \equiv TransIMISSIONOBJECT = \{Itr7.1,\ Itr7.2\};$
$Itr8 \equiv TransIMISSIONCOMMON = \{Itr8.1,\ Itr8.2\};$
$Itr9 \equiv TransIMISSIONVULNERABILITY = \{Itr9.1,\ Itr9.2\};$
$Itr10 \equiv TransIMISSIONPROTECTION = \{Itr10.1,\ Itr10.2,\ Itr10.3,\ Itr10.4,\ Itr10.5,\ Itr10.6\};$
$Itr11 \equiv TransIMISSIONHARM = \{Itr11(1),\ Itr11(2)\};$
$Itr12 \equiv RETURNPROTECTION = \{Itr12.1, Itr12.2\}.$

The elements of each of these subsystems at the right side of equations (5) are presented in details in (L. Vladimirov, 2012). They can be adapted without limitation for all sorts of situations of transboundary environmental risks so, they are universal.

The whole system formalization of trans-border environmental dangers is open and can be updated and developed. In (L. Vladimirov, 2012) it is introduced a general formalization of trans-border conflict-free and conflict situations of environmental impacts.

Non-conflict situations of transboundary environmental impacts are defined as cases in which the behavior of the medium $ENVI_{Crossimpact}$ does not depend on the system's behavior impacts on it $S_{Crossimpact}$. These are situations where there is no trans-border transmission. There is only transfer of pollutants in the country of origin of environmentally hazardous economic activities. Therefore, trans-border situation is security, but dangerous to national borders, in the cases when adverse consequences are prevailing.

In other words, the negative effects of the territory of the affected country can not be explained by the activity of the country of origin. The situation is dangerous at national level - the country of origin or in the territory of the affected country under the influence of impacts from sources within its territory. Such separation and rejection of the possibility of occurrence of environmental hazards, we found far-fetched. Formally speaking, the country of origin may be a danger, while the territory of the bordering country in no dangers to find.

We consider more appropriately to be regarded as a staging base the environmentally dangerous situation, and environmentally security situation to be regarded as a specific case. From a preventive point of view, this assumption is completely justified.

In other words, the transboundary impacts should be taken as a result of common environmental hazards phenomenons and impacts on the national borders of the country of origin as unusual, specific environmentally hazardous phenomenon. Such an admission would make an easier regulation of the complex international relationshiops related to the border environmental problems settlement. The aim is to define and regulate precisely the trans-border just as it is - a complex and difficult problem to solve in international context.

On its own territory the management is simpler and coordination is based on the local national regulations. In other words, you first need to tackle transboundary environmental impacts, then impacts on the territory of the country that they are generated. This means that in trans-border environmental impacts must be considered as dangerous. This assumption is in the initial definition of the problems with the economic activities in border areas. The design of economic activities in border areas mainly must be based on the trans-border danger rather than national environmental danger in the country of origin of the dangerous phenomenon.

Continuing systematic development of transboundary impacts and specifying the principles reasoning dangers in this initial work it was focused on the transboundary danger situations occurring when no transboundary pollution and other impacts are off. The situation of transboundary impacts is a complex structure and differs significantly from the national border phenomenons occurring in the country of origin of the activity, creating environmental dangers.

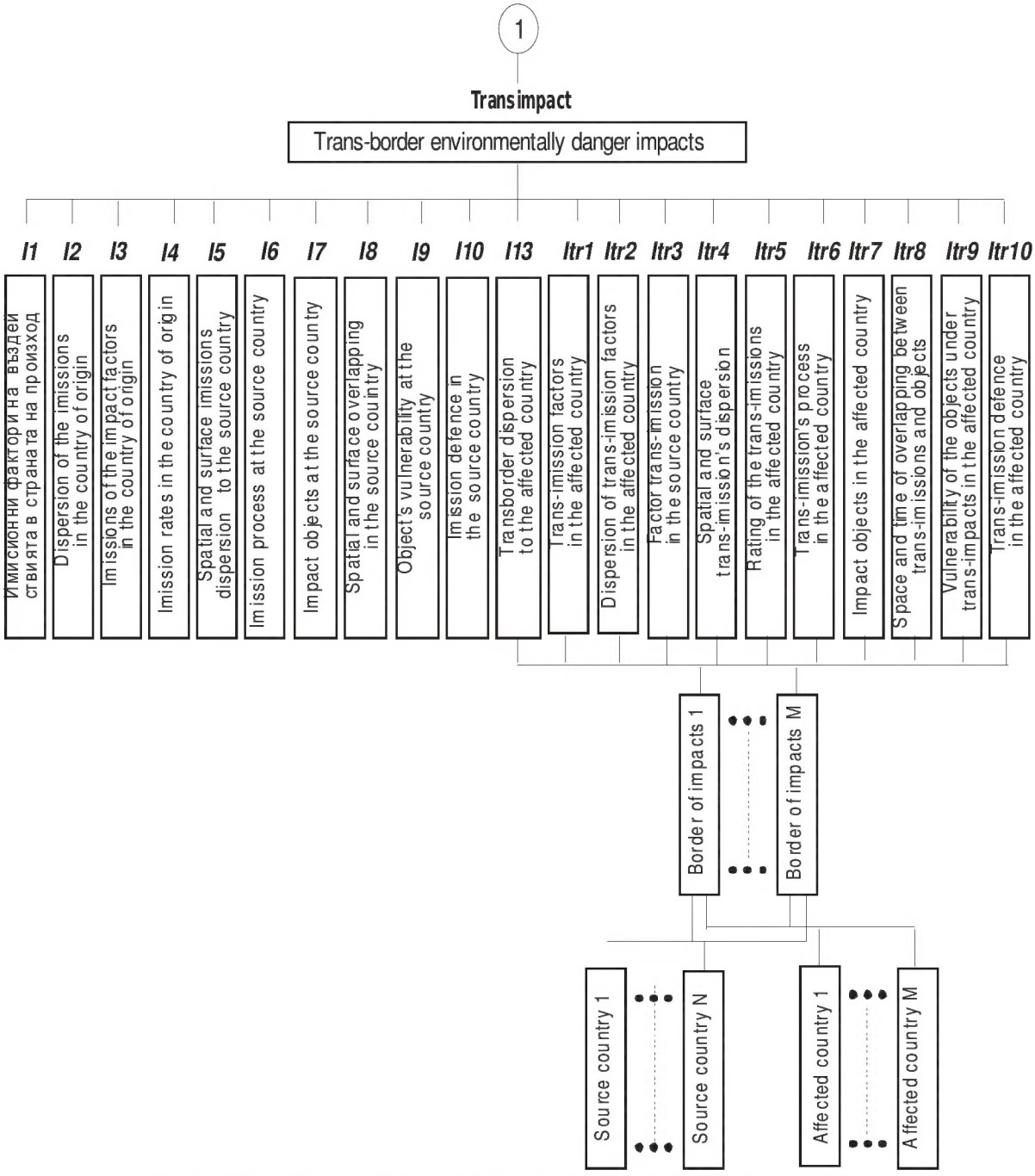

Fig. 2. Lexicological-graphic model of cross-border environmental danger impacts

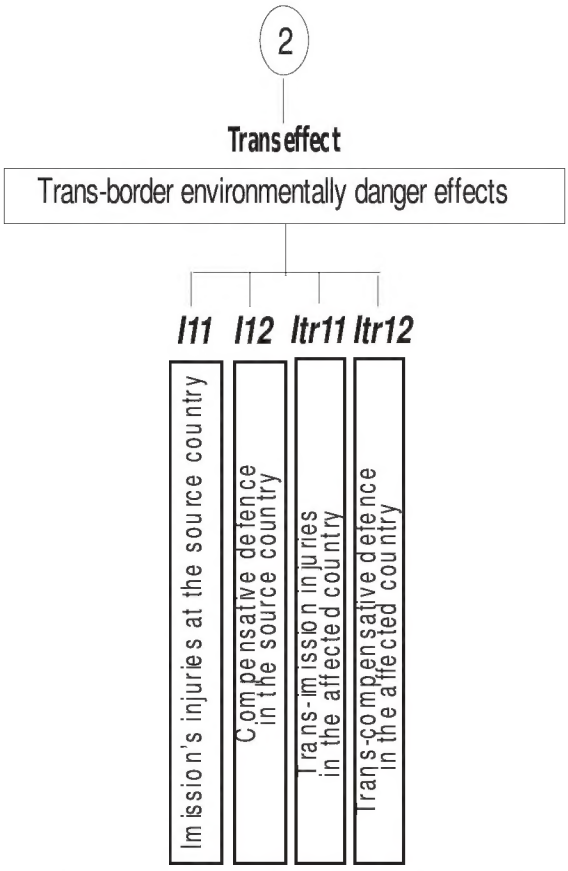

Fig. 3. Lexicological-graphic model of transboundary environmental danger effects

The complexity of the system $S_{Crossimpact}$ requires the use of an experimental method, which allows playback of all the diversity of appearance and development. The method is provided for objectively reproducing system. An argument for this is lack of information that occurs due to complex and lengthy periods of international relations on issues of environmental security. Man, or - generally - the people are one of the systems involved in the system's functionality.

People are subjects to the effects of the urban and natural environment of the socio - economic environment. They design systems for transboundary impacts, they analyze, evaluate and manage. This fact increases the complexity of the problem of transboundary environmental impacts, respectively, phenomenons generating them. Foregoing allows us to analyze the system of cross-border impacts, respectively, phenomenons as complete organization, which includes systems with different performance characteristics.

The maximum effectiveness E of conflict-free cross-border impacts of such situations corresponding to subjective management actions necessary to preserve the situation without transboundary transfer:

$$\max_{\varphi} E_i \longleftrightarrow \varphi_o \qquad (6)$$

The specific management actions are defensive actions that are decomposed into:

Group I. Preventive security measures $F4 \equiv PROFILEPROTECTION$:

1) Design $F4.1\,T \rightarrow$ Technical - Economic Reference $F4.1(1...k)$, 2) Operation and maintenance $F4.2 \rightarrow$ Equipment support , $F4.2(1...l)$ 3) Control $F4.3 \rightarrow$ Checking the emission levels $F4.3(1...m)$.

Group II. Preventive protective actions at the source of the factors of environmental impacts in the country of origin $F6.1 \rightarrow$ 1) Waste gases: sulfur oxides $F6.1(1...k)$,

2) Wastewater Treatment $F6.2 \rightarrow$ Animal fats $F6.2(1...l)$; 3) Solid Waste $F6.3 \rightarrow$ Disposal Hazardous Waste $F6.3(1...m)$;4) Other technologal defences $F6.4 \rightarrow$ Anti erosion technologies $F6.4(1...n)$.

Group III. Imission protection of the origin country $I10 \equiv IMISSIONPROTECTION$: 1) Distance protection $I10.1 \rightarrow$ Distance from the imission area $I10.1(1...k),...I10.1(1...n)$; 2) Exposition protection $I10.2 \rightarrow$ Duration time in the imission border zone $I10.2(1...k),...I10.2(1...n)$; 3) Personal protection $I10.3 \rightarrow$ Personal protective equipment $I10.3(1...k),...I10.3(1...n)$; 4) Legal Defense $I10.4 \rightarrow$ Environmental Law and Litigation $I10.4(1...k),...I10.4(1...n)$; 5) Social Protection $I10.5 \rightarrow$ Social bonuses to stay in imission frontier zone $I10.5(1...k),...I10.5(1...n)$; 6) Data Protection $I10.6 \rightarrow$ Informing of the population $I10.2(1...k),...I10.2(1...n)$;

Group IV. Compensative protection in the country of origin $I12 \equiv RETURNPROTECTION$: 1) Recovery of damages $I12.1 \rightarrow$ Cost Recovery $I12.1(1...k) \rightarrow$ Recovery time $I12.1(1...l)$; 2) Damage compensation $I12.2 \rightarrow$ Damage costs $I12.2(1...k)$.

Group V. Transimisionna protect the territory of the country $Itr10 \equiv TransIMISSIONPROTECTION$: 1) Remote protection $Itr10.1 \rightarrow$ Distance from imission border zone $Itr10.1(1...k),...Itr10.1(1...n)$; 2) Exposure protection $Itr10.2 \rightarrow$ Time, spended in imission border zone $Itr10.2(1...k),...Itr10.2(1...n)$; 3) Personal protection $Itr10.3 \rightarrow$ Individual protection equipment $Itr10.3(1...k),...Itr10.3(1...n)$; 4) Legal Defense $Itr10.4 \rightarrow$ Environmental Law and Litigation $Itr10.4(1...k),...Itr10.4(1...n)$; 5) Social Social Protection $Itr10.5 \rightarrow$ Bonuses to stay at the imission frontier zone $Itr10.5(1...k),...Itr10.5(1...n)$; 6) Data Protection $Itr10.6 \rightarrow$ Information for the population $Itr10.6(1...k),...Itr10.6(1...n)$.

Group VI. Trans-compensative protectrction at the territory of the affected country $Itr12 \equiv RETURNPROTECTION$:1) Reimbursement of the costs $Itr12.1 \rightarrow$ Expenditure for damage recovery $Itr12.1(1...k) \rightarrow$ Recovery time $Itr12.1(1...l)$; 2) Compensation for the damages $Itr12.2 \rightarrow$ Compensation costs $Itr12.2(1...k)$.

A similar decomposition is applied to all subsystems, which are described on the left side of equations (5).

Analyzing the patterns of transboundary environmental dangers it is seen that there arealternative actions that affect a large part of the subsystems of transboundary environmental danger phenomena, impacts and effects.

In a particular management strategy the effect of impacts

$$E = Q - C,$$

where Q are the positive effects - benefits, and C - adverse effects-damages. The aim is the maximum effect of cross-border impact on the environment tends to 0, i.e $\max_{\varphi} E_i \rightarrow 0$. It occurs when the benefits $Q \rightarrow 0$ and the injuries $C \rightarrow 0$. The criterion of effectiveness CE will be in an area with limitations in D_E:

$$CE \in D_E \qquad (7)$$

where D_E is a set of numerical values R_D or $D_E \in R_D$.

Therefore it must be found a range of meanings $I_o = [a_o, b_o]$ to determine the criterion of effectiveness CE. A numeric field or axis R_D where are intervals $I_o, I_1, I_2, ..., I_n$ each of which contains at least one point of the multitude D_E of criteria of effectiveness CE is able to find.

In the conflict situations of transboundary, the management actions should be directed at minimizing the harmful effects and maximizing the beneficial effects. The task can be transformed to minimize the maximum values of the harmful effects or maximize the minimum values of the beneficial effects. Such joint management approaches can be reached by variety of the effects and management actions.

The effects variety can be explained by different impacts, each of which may have not only one but several adverse properties. However, opportunities for protection or management actions, respectively, are also different and the choice of one of them requires analysis of all the actions.

The space of the system's states of cross-border impacts, however, remains a - D_s. The management can be realized through the implementation of a finite number of management actions $\varphi(q)$ that can be $\varphi_1(q), \varphi_2(q), ..., \varphi_m(q)$ and to form the multitude D_φ.

The nature of the environment $ENVI_{Crossimpact}$ must take into account: 1) the natural environment $ENVI_{Nature}$ 2) The urban Environment $ENVI_{Urban}$, 3) The socio - economic environment $ENVI_{Social}$.The reaction of the environment $ENVI_{Nature}$ belongs to the multitude D_g is $g(q)$. In non-conflict situations it is a natural reaction. In it the subject of management is not involved.

The actions of the urban environment $ENVI_{Urban}$ and the socio - economic environment $ENVI_{Social}$ are $\psi_1(q), \psi_2(q), ..., \psi_n(q)$. They belong to the multitude D_ψ of possible actions. We classify them as actions in which the entity participates in the structure of $ENVI_{Urban}$ and $ENVI_{Social}$.

For management of the system of transboundary environmental impacts $S_{Crossimpact}$ must be choosen a particular action $\varphi_i(q)$, under the circumstance of sufficient complete information to the reaction of the $ENVI_{Urban}$ and $ENVI_{Social}$.

The $ENVI_{Crossimpact}$ and its components $ENVI_{Nature}$, $ENVI_{Urban}$, and $ENVI_{Social}$ have a finite number of effects of impacts. At each it corresponds a criterion of effectiveness $CE_{ij} = CE(\varphi_i, g_i)$. Further, the task can be reduced to solutions that are sought by the game theory. Variants of such solutions are presented in (L.Vladimirov, 2012).

3. CONCLUSION

Summarizing the above it can be argued that to solve the problem of transboundary impacts it is imperative to:

First, it must be accepted precise definition of the dangers and threats, as done above. Second, it is necessary to establish a morphological model of cross-border dangers, set out in Figure no.1, no. 2 and no.3 their detailed structure. Third, to formulate analytical models that show the elements and indicators of morphological models. Fourth, to determine the system structure necessary for management to adopt the criterion of the effectiveness of cross-border impacts - basis for analysis and adoption of management decisions to protect the border environment.

The previewed approach is the basis and guarantee for making correct and effective solutions to protect the environment from the impacts of the economic activities in cross-border areas.

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